LEEDS (A.R.)

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Compliments of

ALBERT R. LEEDS,

Stevens Institute of Technology,

Hoboken, N. J.

THE COMPOSITION AND METHODS

—OF—

ANALYSIS OF HUMAN MILK.

BY PROF. ALBERT R. LEEDS, PH.D.

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THE COMPOSITION AND METHODS OF ANALYSIS OF HUMAN MILK.

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IN a previous paper, "On Infant Foods," which I read before the College of Physicians of Philadelphia, May 2, 1882, I alluded briefly to the investigation then in progress upon the Composition of Human Milk, and gave a tabular statement of the minimum, maximum, and average results of the analyses of 43 samples, the total number of analyses which I had made up to that date. Since then I have analyzed 37 more samples, and have verified the results by a critical examination of the various methods of analysis which are in use at the present time.

In the beginning of my previous paper, I asked the question, "What is human milk?" and stated that to answer this question satisfactorily, we should know at least three things: 1st. All the constituents; 2d. Their relative proportion: 3d. Their chemical and physiological properties. It is not my present object to discuss the first and third points, except in the light of the following isolated results which were only incidental to the main object of the present inquiry.

The albuminoids and fat of a large number of samples, as obtained by precipitation with Ritthausen's solution, were extracted with ether, until the albuminate of copper ceased to give up any further traces of fat to the solvent. It then became after drying a very light green amorphous powder.

In order to separate the albuminoids, this powder was digested with very dilute hydrochloric acid, which carries some of the organic matter into solution along with the copper. The residue, after washing and drying at 100°, formed brownish, somewhat brittle, amorphous masses.

The percentage of cupric oxide contained in this albuminate of copper was found in two analyses to be 20.93 per cent., and 20.63 per cent. The ultimate analyses of the albuminate, after deducting cupric oxide, yielded the following results :—

	I. Per cent.	II. Per cent.
Carbon	49.07	49.17
Hydrogen	7.15	7.22
Nitrogen	14.67	----
Sulphur	1.08	1.15

Two analyses of the total albuminoids, left behind after the foregoing treatment of the albuminate of copper with dilute hydrochloric acid, gave the following figures :—

	I. Per cent.	II. Per cent.
Carbon	52.39	----
Hydrogen	7.02	----
Nitrogen	13.64	13.50
Sulphur	1.49	----

The albuminoids, separated by hydrochloric acid from the copper albuminate, were digested with 50 per cent. alcohol, at the boiling point. On cooling, the filtered solution deposited a white flocculent, voluminous precipitate, whilst the residue on the filter formed a somewhat brownish mass.

This precipitate would correspond to the "caseo-protalbin" of Danilewsky (*Jahresb. der Thierch. 1880, 186*), and the residue, which was much the larger in amount, to his "caseo-albumen."

An analysis of the caseo-protalbin gave :—

	Per cent.
Carbon	55.86
Hydrogen	6.07
Nitrogen	17.17

An analysis of the "caseine," obtained by Makris in quite a different manner from Woman's Milk, yielded for its composition, Carbon 52.35 per cent.; Hydrogen 7.27 per cent.; and Nitrogen 14.65 per cent.

The foregoing analyses render evident that the bodies examined are not homogeneous, and in every case the process of separation left behind mixtures of substances the true nature and composition of which are at present unknown. Moreover, the deportment and properties of the bodies examined are such as to lead one to the conclusion that the investigation was being conducted, not upon bodies in the condition and with the properties which they possessed originally in woman's milk, but upon substances whose composition and properties had been altered by the operation of the reagents employed.

It had been the intention of the author to endeavor to isolate the various constituents, at present very imperfectly known, of the fat of human milk. This desire had been increased by the fact that the ethereal extract of the copper albuminate, obtained from numerous samples, although not by any means from all, was colored emerald-green by some copper salt. As to the chemical nature of this copper salt, going as it does in perfect solution in ether, I have no knowledge. Unfortunately, the entire mass of fats was lost by accident in the early stages of manipulation, and I shall have considerable difficulty in again procuring sufficient material to work upon. No sample of cow's milk which I have analyzed yielded to ether an emerald-colored solution. The unknown body is peculiar to woman's milk.

METHODS OF ANALYSIS.

Passing by the methods of analysis which were employed when the nature of the difficulties to be overcome was imperfectly understood, and omitting from discussion in this paper the earliest results as obtained by Meggenhofen, Payen, Henri and Chevallier, L'Héritier. Quevenne, Simon Clemm, Sherer, Donné, Heilen, Regnault and Lehmann, the first method claiming our attention is that made use of by Vernois and Becquerel, in their essay "Du Lait chez la Femme," Paris, 1853.

Although regarded by the authors of the process as the smallest which they could employ, the amount of milk regarded by V. and B. as necessary for analysis is excessive, being 60 grammes.

Total Solids.—Of this, 30 grms. are taken for determination of total solids, which are found by evaporation to constant weight at 80° C. It is evident that the evaporation of so large an amount at so low a temperature not only requires very many hours, but presents great difficulties in the way of expelling the last traces of moisture.

Fat.—The total solids are exhausted on a filter with ether. The loss in weight is set down as fat. Or the ethereal extract after evaporation gives the weight of fat directly.

The estimation of fat by loss of weight involves numerous sources of error. And even the direct estimation according to this method is erroneous, inasmuch as ether very partially exhausts a dried residue of this nature. Consequently, the figures obtained by V. and

B. for fat are much too low, the average in 89 samples being only 2.67 per cent.

The other 30 grms. are coagulated by boiling with some drops of acetic acid. The filtrate contains sugar, extractive matters, and soluble salts.

Milk Sugar.—Its determination by the saccharimeter, as performed by V. and B., gives less accurate results than those obtained by direct chemical methods.

Albuminoids.—The authors regard the nature of the extractive matters as so entirely unknown as to make their determination by analysis impossible, and set down under one head what they denominate "caseum and extractive matters." Its amount is found by subtracting the sum of the weights of fat, sugar, and ash from the total solids. If it were possible by their method to determine these four quantities correctly, the difference, which they style caseum united with extractive matters, would be the albuminoids. But, otherwise, the difference represents the algebraic sum of the errors committed in the various determinations, and this difference, in the present instance, the amount of fat and sugar as stated by V. and B. being much too low, is correspondingly too high, being 3.92 per cent.

Analysis by the same method as that usually employed for Cow's Milk.—This method, which is practiced by some of the public analysts of New Jersey and New York, and which is a somewhat modified form of Wanklyn's, will be found stated in Cairns's Quantitative Analysis, p. 204.

The results obtained on sample of woman's milk, Laboratory No. 1133, were as follows :—

	Per cent.
Ash	0.21
Fat	2.62
Albuminoids	2.60
Milk sugar	8.19
Total solids by summation	13.62
Total solids by evaporation	13.63

The fat, as thus determined, is too low, although it was extracted by digesting the solids left after evaporation with boiling ether six times, and with cold ether as many times more.

The sugar is too high. After weighing it was re-dissolved in water, and the amount of albuminoids contained in it determined. This was 0.78 per cent., which, subtracted from the sugar, as determined in accordance with the method, left 7.41 per cent., which is the correct result.

The albuminoids are also too high, and the excess is still greater when the albuminoids contained in the sugar are added to those as determined in accordance with the method, the total being 3.38 per cent. This excess is due to fat.

Correcting the results, as found directly by the method, by the results obtained by separately analyzing the various educts, we have :

	Per cent.	Per cent.
Fat, determined by method	2.62	
Fat, extracted from casein residue	2.18	
Actual fat		4.80
Albuminoids, determined by method	2.60	
Albuminoids, contained in sugar	0.78	
Sum of albuminoids	3.38	
Deduct fat found in caseine residue	2.18	
Actual albuminoids		1.20
Sugar, determined by method	8.19	
Deduct albumiuoid found in sugar	0.78	
Actual sugar		7.41
Ash		0.21
Total solids, by summation		13.62
Total solids, by direct evaporation		13.63

Determination of the Albuminoids by Precipitation with Acohol.[1] —20 c.c. of dilute acetic acid are added to weak acid reaction, then four volumes of strong alcohol, the mixture well stirred, allowed to settle during an hour, and filtered upon a weighed filter. The precipitate is washed six or eight times with cold sixty per cent. alcohol, then with ether, dried at 120–125° C. and weighed. The alcoholic filtrate is evaporated to small volume, the resultant precipitate transferred by means of sixty per cent. alcohol to a weighed filter, washed repeatedly with the same alcohol, and finally with ether. These filtrates are again evaporated to a small volume, the precipitate obtained dissolved in water, an aqueous solution of tannic acid added, the precipitate so obtained transferred

[1] Handb. der Physiol, Chem. Anal. p. 492. Hoppe-Seyler.

to a weighed filter, washed first with water, then with alcohol and ether, dried at 120° and weighed. The three precipitates together contain all the albuminoids. They must be ignited, and the amounts

[1] Handb. der Physiolog. Chem. Anal. Berlin, 1883, p. 491. Hoppe-Seyler.

of ash deducted. This method gives too low results when the addition of tannic acid is omitted. The trial of this method, as performed on sample, Laboratory No. 1,133, yielded the following results:

	Per cent.
Albuminoids in first precipitate	0.66
" " second precipitate	0.55
" " third "	0.42
Total albuminoids so determined	1.63

The analysis of these albuminoids yielded:

	Per cent.
Fat	0.00
Milk-sugar	0.43

Deducting this amount of milk-sugar, we have:

	Per cent.
Total albuminoids as found	1.63
Deducting milk-sugar	0.43
Albuminoids actually present	1.20

Distilling off the alcohol and ether from the first and second precipitates and determining the milk-sugar in the collected filtrates from the albuminoids, I obtained:

	Per cent.
Fat	4.80
Milk-sugar	6.98

These results make it evident, what, indeed, was feared during the whole course of the analysis by this method, that notwithstanding the great expenditure of time in washing these precipitates, the washing was incomplete, and some milk-sugar was left behind. This supposition is confirmed by the fact that, upon adding the milk-sugar contained in the albuminoid precipitates to that contained in the filtrates, the sum is the correct percentage of sugar.

Determination of the Albumen and Peptone by Precipitation with Magnesium Sulphate.[1]—The assumption upon which this method is founded is that when crystallized magnesium sulphate is added to milk to the point of complete saturation, the caseine is

completely precipitated, whilst the albumen and peptone are not. In the execution of the method, 40 c. c. of a saturated solution of magnesium sulphate are added to 10 grms. of milk, and afterwards crystals of the same salt are added in slight excess of the maximum quantity which can be made to enter into solution. After standing several hours with frequent stirring, the precipitate is transferred to a beaker and washed six or eight times with a saturated solution of magnesium sulphate. The collected filtrates are then diluted with water, a drop or two of acetic acid added, heated to boiling for a few minutes, filtered through a weighed filter, the precipitate washed first with water and afterward with alcohol, dried along with the filter at 120° to 125°, weighed and ignited. By subtracting the weight of ash from that of the precipitate, the amount of albumen is determined.

In the filtrate the peptone can be precipitated by means of tannic acid, or by phospho-tungstic and sulphuric acids.

I failed entirely in an attempt to perform an analysis by this method. Owing to the great density of a saturated solution of magnesium sulphate the caseine did not precipitate, but formed a layer on the surface of the liquid, and so slow was the operation of filtration that I did not succeed in completely washing the caseine during the course of several days.

Haidlen's Method, as Modified by Christenn. Total Solids.—Instead of drying tne milk at 110° with one-fifth of its weight of powdered gypsum, as proposed by Haidlen, Trommer proposed the use of pulverized marble, and Christenn employed powdered glass, the drying being conducted at 95° to 100° instead of 110°. Christenn found that the hygroscopic nature of the gypsum and its solubility in alcohol gave rise to errors, the latter property raising the percentage of milk-sugar and diminishing the percentage of albuminoids.[1]

Other Constituents.—To 10 grms. of milk add 10 c. c. ether add 20 c. c. alcohol, mix thoroughlv, collect the precipitated albuminoids on a weighed filter, and wash with a mixture of ether and alcohol (1:2) until the filtrate runs through clear. The precipitate, dried at 95° to 100°, gives the weight of albuminoids and insoluble salts. By ignition, the weight of the latter is obtained, and the difference gives that of the albuminoids. The weight of evaporated filtrates

[1] The addition of gypsum, marble, glass, sand, etc., is unnecessary and a source of error.

gives the combined weight of fat, milk-sugar, and soluble salts. The loss of weight after extraction with ether gives the fat. The soluble salts and sugar are ignited, the residue treated with hot water, the solution evaporated to dryness, and ignited. The weight of this ignited portion gives the soluble salts, and the milk-sugar is found by difference.

NOTE. In the trial of this method I did not wash the precipitate of albuminoids and insoluble salts on the filter, but by decanting. The precipitate was shaken up six or eight times with the mixture of alcohol and ether, and the latter then pipetted off through a weighed filter. Finally, the albuminoids were thrown on the filter and washed exhaustively with the same mixture. The method of decantation is more rapid and thorough, but even with its aid and with the use in all of 250 c. c. of the mixed solvent, the washing of the albuminoids was incomplete, as shown by the following results of an analysis performed upon the sample, Laboratory No. 1,133.

Analysis according to the Haidlen-Christenn method :—

	Per cent.
Fat	2.90
Albuminoids	2.19
Sugar	8.23
Ash	0.21
Total solids	13.53

These various educts of the Haidlen-Christenn method were analyzed and separated into their individual constituents. The albuminoids were exhausted with ether, and the fat determined in the ethereal solution. The residue was then exhausted with water, and the sugar determined in the aqueous extract. In the final residue, containing according to Haidlen the sugar, the nitrogen was determined directly, and multiplied by 6.25 to obtain the percentage of albuminoids. The nature of the errors inherent in the method is strikingly shown when the corrected results obtained in this manner are compared with those stated in the preceding table :—

	Per cent.	Per cent.
Fat, extracted from the albuminoids	0.76	
Fat, extracted from sugar residue	2.90	
Fat, total as thus found		3.66
Albuminoids, determined by method	2.19	

Deducting fat in albuminoids	0.76	
Deducting sugar in albuminoids	0.16	
Actual albuminoids		1.17
Sugar in albuminoids	0.16	
Sugar in final residue	7.10	
Actual sugar	——	7.26
Ash		0.21
Total solids, as found by summation		12.30
Total solids, as found by evaporation		13.56
Loss		1.26

This loss of 1.26 per cent. represents fat, which I did not succeed in perfectly exhausting from the sugar residue after evaporation to constant weight, although the treatment with ether was performed very many times.

Meigs's Method.[1] *Total Solids and Ash.*—Pipette off 5 c. c. of milk into a platinum dish and weigh. Evaporate to dryness on a water-bath to constant weight. Incinerate, best over a blast-lamp, and weigh the ash.

Fat.—Weigh off 10 c. c. in another dish, and wash with the aid of 20 c. c. of water into a tall 100 c. c. stoppered cylindrical graduate. Add 20 c. c. ether, stopper, shake for five minutes, then add 20 c. c. alcohol, and shake five minutes more.

Allow the cylinder to stand until the ether has risen to the top, pipette off, add 5 c. c. ether, shake, allow to separate, pipette off, and repeat this operation five times. Evaporate off the ether in a weighed dish ; the increase in weight is fat.

Casein and Sugar.—The remaining contents of the graduate, after the ethereal solution of fat has been removed, are washed into a platinum dish and evaporated to dryness on a water-bath. The residue is treated with boiling-water, and allowed to stand. The undissolved casein precipitates, the solution of sugar is poured off. This latter is again evaporated to dryness, and the same process of settling and decantation repeated. This must be done four or five times, until it is found that when boiling water is poured upon the dry sugar it dissolves completely, no flocculi of casein being seen in suspension. The casein residue is then, after being dried, treated once or twice with boiling water to extract sugar.

[1] Philadelphia Medical News, June, 1882.

This sugar is added to the main portion. Both casein and sugar are then evaporated over the water-bath to constant weight, incinerated over a blast-lamp, and the losses in weight give the amounts of casein and sugar respectively.

Experimental Trial of Method. Total Solids.—In the weighing out of milk it must be poured directly into the dish in which it is weighed. If a pipette be used, the milk leaves minute particles upon its walls, and the alteration in composition thus produced is the greater, the more extensive the wetted surfaces of the measuring vessel.

Evaporation to dryness on a water-bath to constant weight is tedious, usually requiring three hours, and is neither so accurate nor so expeditious as the method of coagulation with alchol.

Thus with sample No. 1133 :—

To 5.1195 grms. milk add 3 c. c. alcohol, evaporated to dryness on water-bath, an operation requiring one-half hour, and then to constant weight in air-bath at 105°, requiring with intervals for weighing one hour longer.

Loss of weight 0.699 grm. or 13.56 per cent.

Compare with this the results obtained by direct evaporation without coagulation.

Evaporated 5.059 grms. of same milk for three hours on water-bath.

Loss of weight, 0.6985 grm. or 13.81 per cent.

Dried the same for two hours longer in air-bath at 105°. The weight decreased to 13.59 per cent.

Dried the same for two hours longer at 103°. The weight decreased to 13.56 per cent. In other words, at the expiration of seven hours, I had obtained the same constant weight as I had found by the method of coagulation at the expiration of one and one-half hours.

The explanation of the difficulty of evaporating milk without addition of any kind is evident, the casein coagulated by heat forming a skin upon the surface of the milk which renders any further evaporation very difficult. Alcohol, on the other hand, divides the milk into fine coagula, which readily permit the escape of moisture.

Fat.—When water is present, ether will extract not only fat, but substances soluble in water. This was probably the case in

ERRATA.

p. 262, 5th line from top, for "This residue resolved readily and in water, read, "This residue dissolved readily in water."

p. 266, 9th line from bottom, for "XVI. Height of infant," read, XVI. Weight of infant."

p. 269. In table, 16th line from top, for 9.00, read 0.00 ; 17th line from top, ~~for 80.08~~, read 83.21 ; ~~for 83.21~~, read 89.08.

p. 271, 7th line from top, for 1.0026, read 1.026 ; 10th line from top, for 1034, read 1.034.

p. 279, 19th line from top, for constition, read constitution ; 21st line from top, after "manner," add : But as to any fixed and definite relation governing the proportion of the constituents to each other, or to the sum total of the solid constituents, the graphic chart thus far has failed to afford a satisfactory indication.

the present instance, and experiment confirmed the conjecture. After distilling off the impure either, drying the fat to constant weight at 105° and weighing, the fat thus obtained was redissolved in *absolute* ether. In every trial a residue was left behind. This residue resolved readily and in water. It proved to be milk-sugar, and its percentage was determined and added to that found elsewhere.

Casein and Sugar.—The method has two objections. The albuminoids of milk, and more especially of woman's milk, are partly soluble in boiling water, and cannot be perfectly separated from milk-sugar by its use. In the second place, the finely divided albuminoids left after evaporation to dryness and treatment with boiling water cannot be accurately separated by the crude method of settling and decantation. As a result, in case the albuminoids are washed in this manner so completely that they do not contain any milk-sugar, their amount will be much too low, whilst that of the sugar will be correspondingly too high. The percentage of albuminoids in the milk-sugar was determined by direct determination of contained nitrogen in the following test analyses.

An attempt was made to separate the albuminoids by decantation through a weighed filter, but the process was extremely tedious, the albuminoids so coagulated quickly gumming up the filter paper.

The results obtained were as follows, several analyses being made of the same sample, No. 1133.

	Per cent.
Fat, originally obtained	4.77
Fat, after redissolving in absolute ether	4.66
Containing by direct determination, milk-sugar	0.10
Fat as originally obtained	4.82
Fat, after redissolving in absolute ether	4.48

1st Trial.

Albuminoids in residue	0.79
Albuminoids in milk-sugar	0.63
Total albuminoids	1.42

2d Trial.

Albuminoids on weighed filter	0.36
Albuminoids in milk-sugar	0.71
Total albuminoids	1.07

3d Trial.

Sugar as originally determined	8.30
Add sugar contained in fat	0.34
	8.64
Deduct albuminoids contained in milk-sugar	0.72
Actual milk sugar	7.92

Summary of Analyses.

	Per cent. (1)	Per cent. (2)
Ash (not with blast)	0.21	0.21
Fat	4.77	4.82
Albuminoids	0.79	0.36
Sugar	8.01	8.30
	13.78	13.69

The results obtained by Meigs's method will always differ from those by Hoppe-Seyler's, Haidlen's, and Christenn's methods, and from Ritthausen's method, by giving necessarily a lower percentage of ash, a higher percentage of fat, a lower amount of albuminoids, and a larger percentage of milk-sugar. These differences are inevitable, and depend upon errors inherent in the method.

Gerber-Ritthausen's Method.—After using for a considerable length of time the methods of milk analysis in common use, the author was led by a comparison of the results obtained thereby with those found by Ritthausen's method to abandon the other methods and adopt Ritthausen's. The latter, as modified by Gerber, has now been in constant use in his laboratory for more than two years, and hundreds of analyses have been performed in accordance with it The author regards it as the only method known at the present time, which is precise and rigidly accurate. Moreover, it is so rapid, and, when familiar, so easy of execution, that its employment soon becomes a source of pleasure and satisfaction.

Details of Method. Total Solids.—Weigh off 5 grms. of milk in a tarred, covered, platinum capsule. Coagulate with absolute alchohol (about 3 c.c. are used), and evaporate to dryness on water-bath. Transfer to drying-oven, and keep at 105° C. until constant weight is attained.

Ash.—Ignite the residue first over a small flame, and finally at a dull-red heat. Cover the dish, cool the desiccator, and weigh.

Albuminoids.—Dissolve 63.5 grms. pure sulphate of copper in a liter of water. Prepare also a potash solution containing 50 grms. caustic potash in 1 liter.

Weigh out 10 grms. of milk in a covered beaker glass, and dilute with 100 c.c. water. Add 2.5 to 3 c.c. of the copper solution. Then run in sufficient potash to exactly neutralize the excess of sulphate, which will require about 1.25 to 1.5 c.c. of the potash. The coalagulated albuminoids settle immediately, leaving the liquid clear. In testing the reaction, the stirring-rod, which has been washed and withdrawn from the solution as soon as the potash has been stirred in, is dipped into the clear supernatant liquid. A drop of this liquid should turn neutral test-paper neither blue nor red. Care should be exercised not to allow the stirring-rod to bring up particles of the coagulum, since these interfere with the reaction. The clear liquid is then decanted through a filter-paper, previously dried at 110°, and weighed in a weighing-flask. The precipitate is then stirred up with 100 c.c. water, allowed to settle, the supernatant liquid again decanted through the filter, and, finally, the precipitate is washed upon it. The beaker is thoroughly cleansed with a rubber washer, and all these filtrates, amounting to about 240 c.c., are finally made up to exactly 250 c.c. for the determination of milk-sugar.

The filter paper containing the precipitate is then opened out upon a large watch-glass, and, after drying to a certain point, is divided up into small particles by a platinum spatula, and this comminution is repeated from time to time until finally the whole mass becomes a fine powder.

Fat.—The filter paper containing the precipitate is gathered up and placed loosely in a proper funnel. The beaker-glass used for the precipation is washed out with ether to dissolve any traces of fat adhering to it, and these ethereal washings are poured through the funnel and allowed to run into a small weighed flask, with which the funnel is connected by a ground-glass joint. The funnel is then connected with a return cooler, the flask carefully heated by a water-bath, and the filter paper is made to swim in the ether condensed in the funnel for about an hour, when the extraction of fat will be complete. The ether is distilled off, the flask dried at a temperature of 105°, cooled in a desiccator, and weighed. Its increment in weight gives the amount of fat.

Albuminoids.—The residue in the filter is dried at 110°, and weighed in the weighing flask until constant weight is attained. It is then ignited in a platinum crucible, and the weight of ash deducted. The loss of weight is the amount of albuminoids.

Milk Sugar.—This is determined in the filtrate by Fehling's solution. The figures thus obtained are identical with those found by evaporation of the filtrate to dryness, igniting, and subtracting ash.

In case the above method is carefully followed, the sum of the several constituents as separately determined will not differ by an appreciable quantity from the amount of solid matter as determined directly by evaporation. Thus, it will be seen from the accompanying table, giving the result of 62 separate analyses of human milk (excluding Laboratory No. 1063 as being manifestly affected by some accidental error), the maximum difference is 0.21 per cent.

The average error, as determined by ordinary arithmetical methods, is 0.001 per cent. The probable error of any individual analysis, as determined by the method of least squares, is a difference of 0.0098 per cent. in the sum of the several constituents as found by addition, and the sum as determined by direct evaporation.

This close argument does not itself prove the accuracy of the methods employed. But, in connection with the fact that an analysis of the fat showed no trace of albuminoids or sugar, that an analysis of the albuminoids revealed no sugar or fat, and that an analysis of the sugar showed no albuminoids or fat, it does afford such proof.

The only serious objection to the method is that, in the precipitation of the albuminoids by Ritthausen's solution, hydrated basic sulphate of copper is precipitated at the same time, and that this hydrate does not lose its water at the temperature at which drying of the albuminates is effected. Hence, the weight obtained would be in excess of the true amount. This objection is not borne out by the results of analyses of the precipitated cupric albuminate, since I have failed to detect in it the presence of more than traces of hydrated basic sulphate.

HISTORY OF SAMPLES ANALYZED.

Samples 42 to 55 inclusive were obtained by Dr. K. Parker from inmates of the Infants' Asylum of New York ; all others were obtained by Dr. A. M. Thomas, Chief of Medical Staff of the Emigrants' Asylum and Hospital. Both of these physicians have given their personal attention to the collection of the samples, and in every instance tabulated the physical history of the mother under the following heads :—

I. Mother's name and nationality.
II. Married or single.
III. Age.
IV. Color of hair, etc.; blonde or brunette.
V. Period of lactation.
VI. Right or left breast, or both.
VII. Quantity obtained.
VIII. Time after last nursing.
IX. Time of day.
X. Number of parturitions.
XI. Presence or absence of menstruation.
XII. Present or former illnesses. Child-bed convalescence.
XIII. Physical antecedents of mother and parents.
XIV. Mother's diet.
XV. Health of infant.
XVI. Height of infant at birth, and at collection of sample.
XVII. Age of infant.

It is not necessary to give in detail all these statistics. The mother's diet in every instance was simple, but abundant and nutritious. Only normal milks were analyzed, such as came from healthy women ; these presented, when submitted to the microscope, a normal appearance.

The physical history of mothers and infants is given as far as our present purposes require, in the accompanying tables.

TABLE I.—HISTORY OF SAMPLES ANALYZED.

I.	II.	III.	IV.	V.	VI.		VII.	VIII.	IX.	X.	XI.
No.	Mother's age.	Nationality	Color of hair.	Period of lactation.	Breast. Right	Breast. Left.	Interval since nursing.	Parturitions.	Infant's weight. At birth.	Infant's weight. At present.	Infant's age.
13	28	German	Brown	1 day	....	L.	2 hours	1	6 lbs. 5 oz.	....	3 days.
14	28	German	Dk. b'wn	1 "	....	L.	2 "	2	6 " 12 "	....	3 "
7	19	Irish	Dk. b'wn	2 days	½ R.	½ L.	5 "	1	5 " 11 "	....	Died.
18	..	Nos. 7–35	......	6 "	½ R.	½ L					
28	..	same	......	19 "	....	L.					
35	..	mother	......	29 "	½ R.	½ L.					
47	26	American	Brown	2 "	½ R.	½ L.	2 "	1	9 " 6½ "	....	3 days.
6	33	Pole	Dk. b'wn	2 "	R.	....	5 "	9	7 " 0 "	6 lbs. 12 oz	4 "
38	20	German	Brown	2 "	½ R.	½ L.	3 "	1	8 " 11 "		
15	22	German	Light	3 "	....	L.	2 "	1	9 " 15 "	....	5 "
16	..	No. 15 to	A	5 "	....	L.					
26	..	No. 30	typical	13 "	....	L.	2 "				
29	..	same	Blonde	17 "	....	L.					
30	..	mother	......	27 "	½ R.	½ L.					
40	24	Negress	Black	3 "	½ R.	½ L.	20 min.	1	6 " 0 "	....	4 "
64	24	Hungarian	Black	3 "	R.	....	30 "	2	8 " 6 "	....	4 "
8	29	German	Lt. b'wn	4 "	....	L.	4½ hours	1	8 " 4 "	7 " 12 "	5 "
45	22	American	Brown	5 "	½ R	½ L.	2 "	1	5 " 13½ "	....	5 "
67	28	Scotch	Fair	5 "	½ R.	½ L	30 min.	3	....	....	5 "
41	23	Irish	Black	6 "	½ R.	½ L.	30 "	1	....	....	8 "
21	18	English	Black	8 "	R.	....	1 hour	1	....	....	9 "
32	28	German	Dk. b'wn	10 "	½ R.	½ L.	0 min.	5	....	9 " 0 "	10 "
34	23	German	Brown	10 "	½ R	½ L.	1 hour	2	....	7 " 8 "	10 "
33	23	Irish	Dk. b'wn	11 "	½ R.	½ L	0 "	1	....	8 " 4 "	Dead.
65	..	Dane	Light	12 "	½ R	½ L	1 "	1	....	7 " 12 "	13 days.
4	23	Irish	Dk. b'wn	13 "	....	L.	3 hours	2	7 " 5 "	7 " 10 "	14 "
39	23	Irish	Brown	13 "	½ R.	½ L.	0 "	2	....	....	Dead.
48	22	American	Red	17 "	½ R.	½ L.	2 "	1	....	7 " 1½ "	17 days.
31	20	German	Dk. b'wn	19 "	½ R.	½ L.	½ hour	..	4 " 14 "	5 " 2 "	21 "
24	29	Italian	Black	20 "	½ R.	½ L.	¼ "	2	....	....	21 "
9	29	Irish	Brown	22 "	....	L.	5 hours	5	6 " 10 "	8 " 8 "	24 "
51	16	American	Dk. b'wn	23 "	....	L.	2 "	1	9 " 2 "	....	23 "
68	22	German	Lt. b'wn	23 "	½ R.	½ L.	1 hour	1	....	6 " 3 "	24 "
3	19	German	Brown	25 "	....	L.	4½ hours	1	7 " 0 "	7 " 8 "	27 "
5	21	Irish	Brown	26 "	½ R.	½ L.	6 "	1	6 " 12 "	7 " 8 "	27 "
2	21	Irish	Dk. b'wn	27 "	R.	....	2 "	2	6 " 2 "	8 " 3 "	29 "
66	25	German	Dk. b'wn	30 "	½ R.	½ L.	½ hour	2	....	....	30 "
12	23	Irish	Brown	41 "	....	L.	5 hours	1	[illegible] " 12 "	8 " 13 "	44 "
1	19	German	Brown	45 "	½ R.	½ L.	5 "	1	7 " 8 "	8 " 2 "	45 "
17	..	same as 1	......	49 "	½ R.	½ L.	......	..	....	8 " 5 "	
11	18	German	Lt. b'wn	46 "	....	L.	3 "	1	6 " 0 "	8 " 0 "	48 "
20	30	Slavonic	Brown	50 "	½ R.	½ L.	½ hour	1	5 " 8 "	9 " 8 "	52 "
23	26	Bohemian	Brown	53 "	R.	....	1 "	6	....	....	55 "
10	25	Scotch	Brown	82 "	....	L.	5 hours	2	6 " 10 "	11 " 3 "	83 "
53	19	Irish	Red	88 "	½ R.	½ L.	2 "	1	7 " 8 "	13 " 5 "	88 "
27	28	German	Lt. b'wn	89 "	¼ R.	¾ L.	¾ hour	1	....	....	90 "
52	25	Swedish	Light	90 "	½ R.	½ L.	2 hours	1	7 " 5 "	11 " 3 "	92 "
55	27	German	Brown	93 "	½ R.	½ L.	3 "	1	5 " 8 "	....	Still-born.
25	20	Irish	Brown	115 "	....	L.	2 "	1	7 " 8 "	....	116 days.
19	23	Irish	Dk. b'wn	126 "	½ R.	½ L.	1 hour	1	7 " 8 "	13 " 11 "	128 "
54	19	German	Dk. b'wn	132 "	½ R.	½ L.	2 hours	1	8 " 13 "	14 " 7 "	132 "
43	30	American	Brown	150 "	½ R.	½ L.	2 "	3	7 " 14 "	13 " 4½ "	150 "
42	20	Irish	Brown	167 "	½ R.	½ L.	2 "	1	6 " 13½ "	13 " 12½ "	167 "
22	33	Swedish	Brown	180 "	½ R.	½ L.	¼ hour	1	....	....	Dead.
44	25	American	Light	180 "	½ R.	½ L.	2 hours	3	7 " 12 "	22 " 7 "	182 days.
46	24	Mulatto	Black	186 "	½ R.	½ L.	2 "	2	5 " 13 "	15 " 4½ "	186 "
50	21	American	Lt. b'wn	217 "	½ R.	½ L.	2 "	1	....	15 " 3 "	218 "
49	19	Irish	Lt. b'wn	270 "	½ R.	½ L.	2 "	1	6 " 13 "	16 " 9½ "	272 "
60	25	Scotch	Lt. b'wn	21 "	½ R	½ L.	5 min.	1	....	5 " 8 "	21 "
61	28	German	Brown	12 "	½ R.	½ L.	5 "	2	....	7 " 10 "	13 "
62	30	Irish	Black	27 "	½ R.	½ L.	5 "	1	7 " 8 "	....	29 "
63	22	Irish	Lt. b'wn	19 "	½ R.	½ L.	5 "	1	....	8 " 3 "	21 "
56	..	French	Dk. b'wn	210 "	R.	....	1 hour	5	....	18 " 0 "	210 "
57	..	Irish	Brown	90 "	R.	....	2 hours	1	....	13 " 10 "	90 "
58	..	Irish	Dk. b'wn	153 "	½ R.	½ L.	2 "	1	....	14 " 2 "	153 "
59	..	Irish	Lt. b'wn	92 "	R.	....	2 "	3	....	13 " 4 "	92 "
36	..	....	......	Descriptions lost.							
37											

TABLE II.—ANALYSES OF 80 SAMPLES OF HUMAN MILK.

Number on blank.	Laboratory number	Color.	Spec. grav.	Albuminoids.	Milk-sugar.	Fat.	Solids not fat.	Ash.	Total solids by addition of constituents.	Total solids directly by evaporation.	Difference.
1	1021	Yellow	1.0321	1.44	7.20	5.58	8.81	0.17	14 39	14.46	—0.07
2	1022	......	1.0351	1.68	7.53	3.55	9.42	0.21	12 97	12.84	+0.07
3	1023	White	1.0353	1.96	7.31	4.62	9.45	0.18	14.07	13.96	+0.11
4	1024	......	1.0346	1.73	7.25	2.95	9.19	0.18	12.11	11.96	+0.15
5	1025	White	1.030	1.49	7.23	2.12	8.90	0.18	11.02	11.11	—0.09
6	1026	Yw.-white	1.030	1.45	7.24	3.20	8.93	0.24	12.13	12.10	+0.03
7	1027	Yellow	1.034	3.12	6.47	5.49	9.91	0.32	15.40	15.35	+0.05
8	1028	Yellow	1.030	2.15	6.51	2.31	8.94	0.28	11.25	11.40	—0.15
9	1029	....	1.032	2.05	7.08	3.00	9.26	0.13	12.26	12.31	—0.05
10	1030	......	1.030	1.43	7.19	2.11	8 81	0.19	10.92	10.91	+0.01
11	1031	......	1.031	1.98	6.99	3.06	9.17	0.20	12.23	12.21	+0.02
12	1032	......	1.031	1.76	6.97	2.44	8.93	0.20	11.37	11.40	—0.03
13	1033	......	1.030	2.40	6.45	6.01	9.07	0 22	15.08	15.07	+0.01
14	1034	......	1.032	2.52	6.44	4.95	9.23	0.27	14.18	14.16	+0.02
15	1035	......	1.032	2.18	6.75	2.84	9.06	0.13	11.90	11.88	+0 02
16	1036	Yellow	1.030	0.85	5 50	6.16	6.57	0.22	12.73	12.73	0.00
17	1037	Yellow	1.034	1.49	7.37	5.02	9 03	0.17	14.05	14.18	—0.13
18	1038	Dull-white	1.033	3.95	7.92	4.37	12 09	0.22	16.46	16.55	—0.09
19	1039	......	....	....	....	....	....	0.15	......	12.34	....
20	1040	......	....	....	....	....	...	0.30	......	14.08	....
21	1041	......	....	....	....	....	....	0.22	......	13.01	....
22	1042	......	....	....	....	....	....	0.21	......	12.74	....
23	1043	......	1.030	2.10	6.61	4.02	8.91	0.20	12.93	12.88	+0.05
24	1044	......	[illegible]	1.94	7.45	3.61	9.56	0.16	13 17	13.02	+0.15
25	1045	......	1.032	2.16	7.00	5.84	9.38	0.22	15.22	15.18	+0.04
26	1046	......	1.030	2.08	6.98	3.28	9.26	0.20	12.54	12.39	+0.15
27	1047	......	1.031	1.98	7.00	2.44	9.19	0.21	11.63	11.84	—0.21
28	1048	White	1.031	2.23	7.39	2.95	9.83	0.21	12.78	12.95	—0.17
29	1049	White	1.030	1.81	6.88	2.80	8.89	0.20	11.69	11.70	—0.01
30	1050	Yw.-white	1.031	2.11	7.41	5.04	9.72	0.20	14.76	14.69	+0.07
31	1051	Chalky-white	1.033	2.27	6.75	5.96	9.17	0.15	15.13	15.21	—0.08
32	1052	Yw.-white	1.030	1.53	5.84	5.62	7.21	0.14	12.83	12.99	—0.16
33	1053	Yellow	1.030	2.24	6.25	2.76	8.84	0.35	11.60	11.45	+0.15
34	1054	Chalky-white	1.034	2.19	7.46	6.89	9.90	0.25	16.79	16.66	+0.13
35	1056	White	1.032	2.43	7.34	3.13	9.98	0.21	13.11	13.20	—0 09
36	1057	Yellow	1.031	2.43	7.23	3.79	9.88	0.22	13.67	13.63	+0.04
37	1058	Chalky-white	1.032	1.60	7.55	6.21	9.37	0.22	15 58	15.45	+0.13
38	1064	White	1.021	1.82	6.96	3.97	8.97	0.19	12.94	12.87	+0.07
39	1065	Yw.-white	1.030	2.33	5.78	4.21	8.32	0.21	12.53	12.57	—0.04
40	1066	Yellow	1.032	1.75	6 94	3.68	8.97	0.28	12.65	12.52	+0.13
41	1067	White	1.031	2.45	6.08	3.82	8.72	0.19	12.54	12.41	+0 13
42	1055	White	1.031	1.97	7.38	4.16	9.60	0.25	13.76	13.60	+0.16
43	1059	Chalky-white	1.031	1.50	7.32	3.77	9.00	0.18	12.77	12.64	+0.13
44	1060	White	1.030	1.49	7.31	4.34	9.01	0.21	13.35	13.17	+0.18
45	1061	Yw.-white	1.031	2.33	7.48	2.47	9.97	0.16	12.44	12.36	+0.08
46	1062	White	1.031	1.35	7.24	4.09	8.89	0.31	12.98	13.15	—0.17
47	1063	Yellow	1.032	4.86	5.40	3.36	9.46	0.20	13.82	13.35	+0.47
48	1068	Yw.-white	1.032	1.93	6.95	5.59	9.06	0.18	14 65	14.58	+0.07
49	1069	White	1.031	2.00	6.95	4.64	9.16	0.21	13.80	13.74	+0.06
50	1070	White	1.031	2.06	6.39	4.75	8.62	0.22	13.44	13.48	—0.04
51	1071	Yellow	1.030	2.42	6.95	5.60	9.56	0.19	15.16	15.25	—0.09
52	1072	White	1.030	2.15	6.76	6.78	9.07	0.16	15.85	15.89	—0.04
53	1073	White	1.029	1.82	6.83	4.28	9.02	0.37	13.30	13.30	0.00
54	1074	Yw.-white	1.030	[illegible]	7.34	3.10	8.92	0.18	12.02	12.12	—0.10
55	1075	White	1.026	2.43	6.57	4.94	9.27	0.27	14.21	14 20	+0.01
56–59	1133	......	1.0297	1.16	7.41	4.74	8.78	0.21	13.57	13.63	—0.06
60–63	1134	......	1.0296	1.95	7 02	3.85	9.19	0.22	13.04	13.12	—0.08
64	1135	......	1.0312	2.00	6.69	3.96	9.01	0.32	12.97	13.05	—0.08
65	1137	......	1.0319	2.25	7.12	5.85	9.52	0.15	15.37	15.35	+0.02
66	1138	......	1.0307	1.11	7.07	2.73	8.40	0.22	11.13	11.13	0.00
67	1139	......	1.0322	1.96	7.28	4.74	9.54	0.30	14.28	14.28	0.00
68	1140	......	1.0317	2.17	7.44	4.36	9.90	0.29	14.26	14.26	0.00
Robust	6 cases	......	1.031	1.44	6.94	3.71	8.63	0.25	12.34	12.37	—0.03
Anæmic	6 cases	......	1.031	2.12	6.74	3 96	9.02	0.22	13.10	13.08	+0.02
Maximum		......	1.0353	4.86	7.92	6.89	12.09	0.37	16.79	16.66	0.21
Minimum		......	[illegible]	0.85	5.40	2.11	6.57	0.13	10.92	10.91	0.00
Average		......	1.0313	1.995	6.936	4.131	9.137	0.201	13.268	13.267	0.001

COMPARISON OF FINAL RESULTS WITH PREVIOUS ANALYSES.

Analyses of Eighty Samples of Woman's Milk.

	Reaction uniformly alkaline.		
	Average.	Minimum.	Maximum.
I. Specific gravity	1.0313	1.0260	1.0353
II. Albuminoids	1.995	0.85	4.86
III. Sugar	6.936	5.40	7.92
IV. Fat	4.131	2.11	6.89
V. Solids not fat	9.137	6.57	12.09
VI. Ash	0.201	0.13	0.37
VII. Total solids (by addition of constituents)	13.268	10.92	16.79
VIII. Total solids (directly by evaporation)	13.267	10.91	16.66
IX. Difference between VII. and VIII.	0.001	0.00	0.21
X. Water	86.732	83.21	89.08

The most interesting comparison which can be made is that with the results given by König (*Chemie der Mensch. Nahrungs und Genussmittel*), which are deduced from the analyses of 190 samples. These analyses, it should be remembered, were performed according to the most adverse methods, errors in opposite directions operating to mutually compensate one another.

Analyses of samples of woman's milk (König) :—

	Average.	Maximum.	Minimum.
Albuminoids	1.94	0.57	4.25
Sugar	6.04	4.11	7.80
Fat	3.90	1.71	7.60
Ash	0.49	0.14	1.78(?)
Water	87.09	83.69	90.90

As might be anticipated, the extremes are wider apart than in my own analyses, but the general mean of all, with exception of the ash, is tolerably concordant.

Omitting particular reference to the results of Fernois and Becquerel and earlier investigations, I will quote further only the results of Gerber (mean of six analyses), Christenn and Marchand (*Beilstein's Handb. der Organ. Chem.*, 2081).

	Gerber.	Christenn.	Marchand.
Albuminoids	1.8	1.9	1.7
Sugar	5.4	6.0	7.1
Fat	5.3	4.3	3.7
Solids not fat	7.2	8.2	9.0
Ash	0.4	0.3	0.2
Total solids by evaporation	10.9	12.8	12.7
Water	89.1	87.2	87.3

Biedert (*loc. cit.*) found the albuminoids to vary, in the samples which he analyzed, between 1.5–2.4 per cent.; fat, between 3.8 to 4.4 per cent. His mean for albuminoids is 1.95; my own is 1.995; König's is 1.94 per cent.

Two per cent., therefore, may be regarded, without sensible error, as *the average amount of albuminoids in woman's milk.*

The more extended series of eighty analyses confirm, however, the statements made in my earlier paper (that on Infant Foods), the albuminoids being the most variable constituent of woman's milk, the fat the next most variable, and the sugar the least. Nor have I any reason to alter the interpretation therein given of the physiological signification of the greater and less variability of the individual constituents.

RELATIONS BETWEEN THE PHYSICAL HISTORY OF THE MILK AND ITS COMPOSITION.

Relations between the physical history of the milk and its composition.

The only relations which I shall attempt to discuss here are those appertaining to the

1st. Color, taste, consistency, and specific gravity.

2d. Age of the mother.

3d. Period of lactation, and interval since nursing.

4th. Nationality.

5th. Physical constitution of the mother.

I. *Color, Taste, etc.*—Whether bluish-white, chalky-white, whitish, yellowish-white, or yellow, the color is no indication of the composition. For example, the milk of a German brunette, taken one hour after previous nursing and during the tenth day of lactation, was chalky-white in color, whilst it contained 6.89 per cent. of fat. This was the largest percentage of fat in any sample. On the other hand, though many of the yellow samples were rich in fat, other yellow samples were very poor. Thus, No. 8 was yellow (the milk being drawn during the fourth day of lactation, and four and one-half hours after nursing), while it contained only 2.31 per cent. of fat.

Taste.—Although the amount of sugar in woman's milk is large, being nearly 7 per cent. or 2 per cent. more than in cow's milk, it is rarely sweet to the taste. Usually, it has a more or less saline, somewhat disagreeable animal flavor.

Consistency.—Although the amount of solids in woman's milk is decidedly greater than in cow's milk, its consistency is much thinner and more watery.

Specific Gravity.—The average is somewhat greater than in cow's milk, though the entire range of variation is not very different. Thus, in the 80 samples examined, the average specific gravity is 1.0313, the minimum 1.0026 the maximum 1.0353. Conrad obtained in 130 observations for the two last figures 1.025 and 1.039. In 147 samples of normal cow's milk L. Janke found 1.0245 for the minimum, 1034 for the maximum, and 1.0297 for the mean.

II. *Age of Mother.*—The milk of women under the age of 20 is richer in each and every constituent than that of older women. The general average of *albuminoids* for the first lustrum is 2.18 per cent., while it is only 1.92 per cent. for the second, and 2.10 for the third. The difference is still more striking in regard to sugar. In the first lustrum the sugar is 7.17 per cent., falling to 6.91 in the second lustrum, and in the third only 6.77 per cent. This falling off is notable, not only in the percentages, but in the number of samples which exceed the average. Thus, in the first lustrum, 83 per cent. of the whole number of samples exceed the general average in sugar, while in the second lustrum only 60 per cent. exceed. A similar diminution is observable in the fat and total solids.

TABLE III.—MILK OF WOMEN FROM 15 TO 20 YEARS OF AGE.

(First lustrum.)

A = No. of cases above or below the general average.
B = Averages for A.
C = Averages for women from 15 to 20 years of age.
D = General averages for all years.

No. of sample.	Albuminoids.		Milk sugar.		Fat.		Solids not fat.		Ash.		Total solids.	
	Above av.	Below av.	Above av.	Below av.	Ab. av.	Bel. av.	Above av.	Below av.	Above av.	Below av.	Above av.	Below av.
7	3.12	......	......	6.47	5.49	......	9.91	......	0.32	......	15.35	
18	3.95	......	7.92	......	4.37	......	12.09	......	0.22	......	16.55	
28	2.23	......	7.39	......	......	2.95	9.83	......	0.21	......	....	12.95
35	2.43	......	7.34	......	......	3.13	9.98	......	0.21	......	....	13.20
21	......	......	......	......	......	......	......	......	......	......	....	13.01
51	2.42	......	6.95	......	5.60	......	9.56	......	......	0.19	15.25	
3	......	1.96	7.31	......	4.62	......	9.45	......	......	0.18	13.96	
1	......	1.44	7.20	......	5.58	......	......	8.81	......	0.17	14.46	
17	......	1.49	7.37	......	5.02	......	......	9.03	......	0.17	14.18	
11	......	1.98	6.99	......	......	3.06	9.17	......	......	0.20	....	12.21
53	......	1.82	......	6.83	4.28	......	......	9.02	0.37	......	13.30	
54	......	1.50	7.34	......	......	3.10	......	8.92	......	0.18	....	12.12
49	2.00	......	6.95	......	4.64	......	9.16	......	0.21	......	13.74	
A	VI.	VI.	X.	II.	VIII	IV.	VIII.	IV.	VI.	VI.	VIII.	V.
B	2.70	1.69	7.27	6.65	4.95	3.06	9.89	8.94	0.26	0.18	14.60	12.29
C	2.18		7.17		4.32		9.58		0.22		13.87	
D	1.995		6.936		4.131		9.137		0.201		13.267	

TABLE IV.—MILK OF WOMEN FROM 20 TO 25 YEARS OF AGE.

(Second lustrum.)

A = No. of cases above or below the general average.
B = Averages for A.
C = Averages for women from 20 to 25 years of age.

No. of sample.	Albuminoids.		Milk-sugar.		Fat.		Solids not fat.		Ash.		Total solids.	
	Above av.	Below av.	Above av.	Below av.	Ab. av.	Bel. av.	Above av.	Below av.	Above av.	Below av.	Above av.	Below av.
38	......	1.82	6.96	......	......	3.97	......	8.97	......	0.19	....	12.87
15	2.18	......	......	6.75	......	2.84	......	9.06	......	0.13	....	11.88
16	......	0.85	......	5.50	6.10	......	......	6.57	0.22	......	....	12.73
29	......	1.81	......	6.88	......	2.80	......	8.89	......	0.20	....	11.70
30	2.11	......	7.41	......	5.04	......	9.72	......	......	0.20	14.69	
40	......	1.75	......	6.94	......	3.68	......	8.97	0.28	......	....	12.52
64	2.00	......	......	6.69	......	3.96	......	9.01	0.32	......	13.05	
45	2.33	......	7.48	......	......	2.47	9.97	......	......	0.16	....	12.36
43	......	1.50	7.32	......	......	3.77	......	9.00	......	0.18	....	12.64
34	2.19	......	7.46	......	6.89	......	9.90	......	0.25	......	16.66	
33	2.24	......	......	6.25	......	2.76	......	8.84	0.35	......	....	11.45
4	......	1.73	7.25	......	......	2.95	9.19	......	......	0.18	....	11.96
39	2.33	......	......	5.78	4.21	......	......	8.32	0.21	......	....	12.57
48	......	1.93	6.95	......	5.59	......	......	9.06	......	0.18	14.58	
31	2.27	......	......	6.75	5.96	......	9.17	......	......	0.15	15.21	
68	2.17	......	7.44	......	4.36	......	9.90	......	0.29	......	14.26	
5	......	1.49	7.23	......	......	2.12	......	8.90	......	0.18	....	11.11
2	......	1.68	7.53	......	......	3.55	9.42	......	0.21	......	....	12.84
12	......	1.76	6.97	......	......	2.44	.. ...	8.93	......	0.20	....	11.40
25	2.16	......	7.00	......	5.84	......	9.38	......	0.22	......	15.18	
42	......	1.97	7.38	......	4.16	......	9.60	......	0.25	......	13.60	
33	2.24	......	.....	6.25	......	2.76	......	8.84	0.35	......	....	11.45
46	......	1.35	7.24	......	......	4.09	......	8.89	0.30	......	....	13.15
50	2.06	......	......	6.39	4.75	......	......	8.67	0.22	......	13.48	
26	2.08	......	......	......	......	3.28						
19	......	......	......	......	......	......	......	......	......	0.15	....	12.34
A	XIII.	XII.	XIV.	X.	X.	XV.	IX.	XV.	XIII.	XII.	IX.	XVI.
B	2.18	1.64	7.26	6.41	5.40	3.16	9.58	8.80	0.27	0.17	14.52	12.18
C	1.92		6.91		4.05		9.09		0.22		13.02	

TABLE V.—MILK OF WOMEN FROM 25 TO 30 YEARS OF AGE.

(Third lustrum.)

A = No. of cases above or below the general average.
B = Averages for A.
C = Averages for women from 25 to 30 years of age.
D = General averages for all ages.

No. of sample.	Albuminoids.		Milk-sugar.		Fat.		Solids not fat.		Ash.		Total solids.	
	Above av.	Below av.	Above av.	Below av.	Ab. av.	Bel. av.	Above av.	Below av	Above av.	Below av.	Above av.	Below av.
13	2.40	......	......	6.45	6.01	......	......	9.07	0.22	......	15.07	
14	2.52	......	......	6.44	4.95	......	9.23	......	0.27	......	14.16	
47	4.86	......	......	5.40	......	3.36	9.46	......	......	0.20	13.35	
8	2.15	......	......	6.51	......	2.31	......	8.94	0.28	......	....	11.40
67	......	1.96	7.28	......	4.74	......	9.54	......	0.30	......	14.28	
32	......	1.53	......	5.84	5.62	......	......	7.21	......	0.14	....	12.99
24	......	1.94	7.45	......	......	3.61	9.56	......	......	0.16	....	13.02
9	2.05	......	7.08	......	......	3.00	9.26	......	......	0.13	....	12.31
66	...	1.11	7.07	......	......	2.73	......	8.40	0.22	......	....	11.13
23	2.10	......	......	6.61	......	4.02	......	8.91	......	0.20	....	12.88
10	......	1.45	7.19	......	......	2.11	......	8.81	......	0.19	....	10.91
27	1.98	......	7.00	......	......	2.44	9.19	......	0.21	......	....	11.84
52	2.15	......	......	6.76	6.78	......	......	9.07	......	0.16	15.89	
55	2.43	......	......	6.57	4.94	......	9.27	......	0.27	......	14.20	
43	......	1.50	7.32	......	......	3.77	......	9.00	......	0.18	....	12.64
44	......	1.49	7.31	......	4.34	......	......	9.01	0.21	......	....	13.17
A	VIII.	VIII.	VIII.	VIII.	VII.	IX.	VII.	IX.	VIII.	VIII.	VI.	X.
B	2.58	1.62	7.21	6.32	5.34	3.04	9.36	8.71	0.25	0.17	14.49	12.23
C	2.10		6.77		4.04		9.00		0.21		13.08	
D	1.995		6.936		4.131		9.137		0.201		13.267	

This research affords no adequate data as to the rate of decrease beyond the age of 30 years. The only complete analysis bearing upon this point is that of the milk of a dark haired, black eyed swarthy Pole, of gross habit and enormous breast development, who, at the age of 33 years, had been the mother of nine children. Two ounces were drawn from the right breast only, five hours after previous nursing. It was low in specific gravity, and yellow in color. It contained :—

	Per cent.
Albuminoids	2.24
Sugar	6.25
Fat	2.75
Solids not fat	8.84
Ash	0.35
Total solids	11.45

III. *Period of Lactation, etc.*—If we divide this period into four intervals, the first extending from the beginning of lactation to the eleventh day after; the second from the eleventh to the thirty-first day; the third from the thirty-first to the ninety-first day; the fourth from the ninety-first day to the tenth month of lactation, we shall note the following changes:—

Albuminoids are greatest in the first interval, being 2.32 per cent. In the second, they exceed the general average, being 2.09 per cent. In the third interval they fall as much below the average as in the first they exceeded it, remaining at a low figure during the rest of lactation.

Sugar is least immediately after parturition and much below the average, whilst it is above and nearly constant during the three remaining periods.

Fat, like the albuminoids, is much in excess of the general average immediately after parturition, being 4.93 per cent. After the eleventh day it falls, being only 3.97 per cent.

The saline constituents are nearly constant during all stages of lactation, although slightly in excess during the first ten days.

The sum of solids not including fat does not vary greatly. Its amount in the first interval is 9.15 per cent., the general average being 9.14.

Interval since Nursing.—Nearly all the samples were drawn two hours after nursing, but certain ones, more especially Nos. 18, 32, 33, 39, were drawn immediately. In fat, albuminoids, salts, and total solids, they were in excess of the general average.

TABLE VI.—MILK OF WOMEN FROM FIRST TO ELEVENTH DAY OF LACTATION.

A = No. of cases above or below the general average.
B = Averages for A.
C = Averages from the first to eleventh day of lactation.
D = General averages from the 1st to 270th day of lactation.

No. of sample.	Day.	Albuminoids		Milk-sugar.		Fat.		Solids not fat.		Ash.		Total solids.	
		Ab've av.	Bel'w av.	Ab've av.	Bel'w av.	Ab've av.	Bel'w av.	Ab've av.	Bel'w av.	Ab've av.	Bel'w av.	Above av.	Below av.
13	1	2.40	......	......	6.45	6.01	......	......	9.07	0.22	......	15.07	
14	1	2.52	......	......	6.44	4.95	......	9.23	......	0.27	......	14.16	
7	2	3.12	......	......	6.47	5.49	......	9.91	......	0.32	......	15.35	
47	2	4.86	......	......	5.40	......	3.36	9.46	......	......	0.20	13.35	
6	2	......	1.45	7.24	......	......	3.20	......	8.93	0.24	......	....	12.10
38	2	......	1.82	6.96	......	......	3.97	......	8.97	......	0.19	....	12.87
15	3	2.18	......	......	6.75	......	2.84	......	9.06	......	0.13	....	11.88
40	3	......	1.75	......	6.94	......	3.68	......	8.97	0.28	......	....	12.52
64	3	2.00	......	......	6.69	......	3.96	......	9.01	0.32	......	13.05	
8	4	2.15	......	......	6.51	......	2.31	......	8.94	0.28	......	....	11.40
16	5	......	0.85	......	5.50	6.16	......	......	6.57	0.22	......	....	12.73
45	5	2.33	......	7.48	......	......	2.47	9.97	......	......	0.16	....	12.36
67	5	......	1.96	7.28	......	4.74	......	9.54	......	0.30	......	14.28	
18	6	3.95	......	7.92	......	4.37	......	12.09	......	0.22	......	16.55	
41	6	2.45	......	......	6.08	......	3.82	......	8.72	......	0.19	....	12.41
21	8	......	......	......	......	......	......	......	......	......	......	....	13.01
32	10	......	1.53	......	5.84	5.62	......	......	7.21	......	0.14	....	12.99
34	10	2.19	......	7.46	......	6.89	......	9.90	......	0.25	......	16.66	
A		XI.	VI.	VI.	XI.	VIII.	IX.	VII.	X.	XI.	VI.	VIII.	X.
B		2.74	1.56	7.40	6.28	5.53	3.29	10.01	8.54	0.26	0.17	14.81	12.43
C		2.32		6.67		4.93		9.15		0.23		13.48	
D		1.995		6.936		4.131		9.137		0.201		13.267	

TABLE VII.—MILK OF WOMEN FROM THE 11TH TO 31ST DAY OF LACTATION.

No. of sample.	Day.	Albuminoids Ab've av.	Albuminoids Bel'w av.	Milk-sugar. Ab've av.	Milk-sugar. Bel'w av.	Fat. Ab've av.	Fat. Bel'w av.	Solids not fat. Ab've av.	Solids not fat. Bel'w av.	Ash. Ab've av.	Ash. Bel'w av.	Total solids. Above av.	Total solids. Below av.
33	11	2.24	......	......	6.25	......	2.76	......	8.84	0.35	......	....	11.45
65	12	2.25	......	7.12	......	5.85	......	9.52	......	......	0.15	15.35	
26	13	2.08	......	6.98	......	......	3.28	9.26	......	......	0.20	....	12.39
4	13	......	1.73	7.25	......	......	2.95	9.19	......	......	0.18	....	11.96
39	13	2.33	......	......	5.78	4.21	......	......	8.32	0.21	......	....	12.57
29	17	......	1.81	......	6.88	......	2.80	......	8.89	......	0.20	14.69	
48	17	......	1.93	......	......	5.59	......	......	9.06	......	0.18	14.58	
28	19	2.23	......	7.39	......	......	2.95	9.83	......	0.21	......	....	12.95
31	19	2.27	......	......	6.75	5.96	......	9.17	......	......	0.15	15.21	
24	20	......	1.94	7.45	......	......	3.61	9.56	......	......	0.16	....	13.02
9	22	2.05	......	7.08	......	......	3.00	9.26	......	......	0.13	....	12.31
51	23	2.42	......	6.95	......	5.60	......	9.56	......	......	0.19	15.25	
68	23	2.17	.....	7.44	......	4.36	......	9.90	......	0.29	......	14.26	
3	25	......	1.96	7.31	......	4.62	......	9.45	......	......	0.18	13.96	
5	26	......	1.49	7.23	......	......	2.12	......	8.90	......	0.18	....	11.11
60–3	26	......	1.95	7.02	......	......	3.85	9.19	......	0.22	......	....	13.12
2	27	......	1.68	7.53	......	......	3.55	9.42	......	0.21	......	....	12.84
30	27	2.11	......	7.41	......	5.04	......	9.72	......	......	0.20	14.69	
35	29	2.43	......	7.34	......	......	3.13	9.98	......	0.21	......	....	13.20
66	30	......	1.11	7.07	......	......	2.73	......	8.40	0.22	......	....	11.13
A		XI.	IX.	XVI.	IV.	VIII.	XII.	XIV.	VI.	VIII.	XII.	VIII.	XII.
B		2.23	1.76	7.22	6.42	5.02	3.23	9.50	8.74	0.24	0.17	14.75	12.25
C		2.09		7.06		4.00		9.27		0.201		13.25	
D		1.995		6.936		4.131		9.137		0.201		13.267	

TABLE VIII.—MILK OF WOMEN FROM THE 31ST TO 91ST DAY OF LACTATION.

No. of sample.	Day.	Albuminoids Ab've av.	Albuminoids Bel'w av.	Milk-sugar. Ab've av.	Milk-sugar. Bel'w av.	Fat. Ab've av.	Fat. Bel'w av.	Solids not fat. Ab've av.	Solids not fat. Bel'w av.	Ash. Ab've av.	Ash. Bel'w av.	Total solids. Above av.	Total solids. Below av.
12	41	......	1.76	6.97	......	......	2.44	......	8.93	......	0.20	....	11.40
1	45	......	1.44	7.20	......	5.58	......	......	8.81	......	0.17	14.46	....
17	49	......	1.49	7.37	......	5.02	.....	......	9.03	......	0.17	14.18	....
11	18	......	1.98	6.99	......	......	3.06	9.17	......	......	0.20	....	12.21
20	50	......	......	......	......	......	......	......	......	0.30	......	14.08	....
23	53	2.10	......	......	6.61	......	4.02	......	8.91	......	0.20	....	12.88
10	82	......	1.45	7.19	......	......	2.11	......	8.81	......	0.19	....	10.91
53	88	......	1.82	......	6.83	4.28	......	......	9.02	0.37	......	13.30	....
27	89	1.98	......	7.00	......	......	2.44	9.19	......	0.21	......	....	11.84
52	90	2.15	......	......	6.76	6.78	......	......	9.07	......	0.16	15.89	....
A		III.	VI.	VI.	III.	IV.	V.	II.	VII.	III.	VII.	V.	V.
B		2.07	1.66	7.12	6.73	5.41	2.81	9.18	8.94	0.29	0.18	14.38	11.85
C		1.60		6.99		3.97		8.99		0.22		13.11	
D		1.995		6.936		4.131		9.137		0.201		13.267	

TABLE IX.—MILK OF WOMEN FROM THE 91ST DAY TO THE 10TH MONTH OF LACTATION.

No. of sample.	Day.	Albuminoids		Milk-sugar.		Fat.		Solids not fat.		Ash.		Total solids.	
		Ab've av.	Bel'w av.	Ab've av.	Bel'w av.	Ab've av.	Bel'w av.	Ab've av.	Bel'w av.	Ab've av.	Bel'w av.	Above av.	Below av.
55	93	2.43	......	......	6.57	4.94	......	9.27	......	0.27	......	14.20	
25	115	2.16	......	7.00	......	5.84	......	9.38	......	0.22	......	15.18	
19	126	......	......	......	......	......	......	......	......	......	0.15	....	12.34
54	132	......	1.50	7.34	......	......	3.10	......	8.92	......	0.18	....	12.12
56–9	136	......	1.16	7.41	......	4.79	......	......	8.78	0.21	......	13.63	
43	150	......	1.50	7.32	......	......	3.77	......	9.00	......	0.18	....	12.64
42	167	......	1.97	7.38	......	4.16	......	9.60	......	0.25	......	13.60	
22	180	......	......	......	......	......	......	......	......	0.21	......	....	12.74
44	180	......	1.49	7.31	......	4.34	......	......	9.01	0.21	......	....	13.17
46	186	......	1.35	7.24	......	......	4.09	......	8.89	0.30	......	....	13.15
50	217	2.06	......	......	6.39	4.75	......	......	8.67	0.22	......	13.48	
49	270	2.00	......	6.95	......	4.64	......	9.16	......	0.21	......	13.74	
A		IV.	VI.	VIII.	II.	VII.	III.	IV.	VI.	IX.	III.	VI.	VI.
B		2.16	1.50	7.24	6.48	4.78	3.65	9.35	8.88	0.23	0.17	13.97	12.69
C		1.78		7.09		4.44		9.07		0.22		13.34	
D		1.995		6.936		4.131		9.137		0.201		13.267	

IV. *Nationality.*—The statistics are entirely too meager to determine the influence of nationality. It would be necessary to obtain for each race a large collection of results, in which the other causes of variation, like age, period of lactation, etc., were allowed for or eliminated. This has never been done, and would require not eighty, but many hundred analyses.

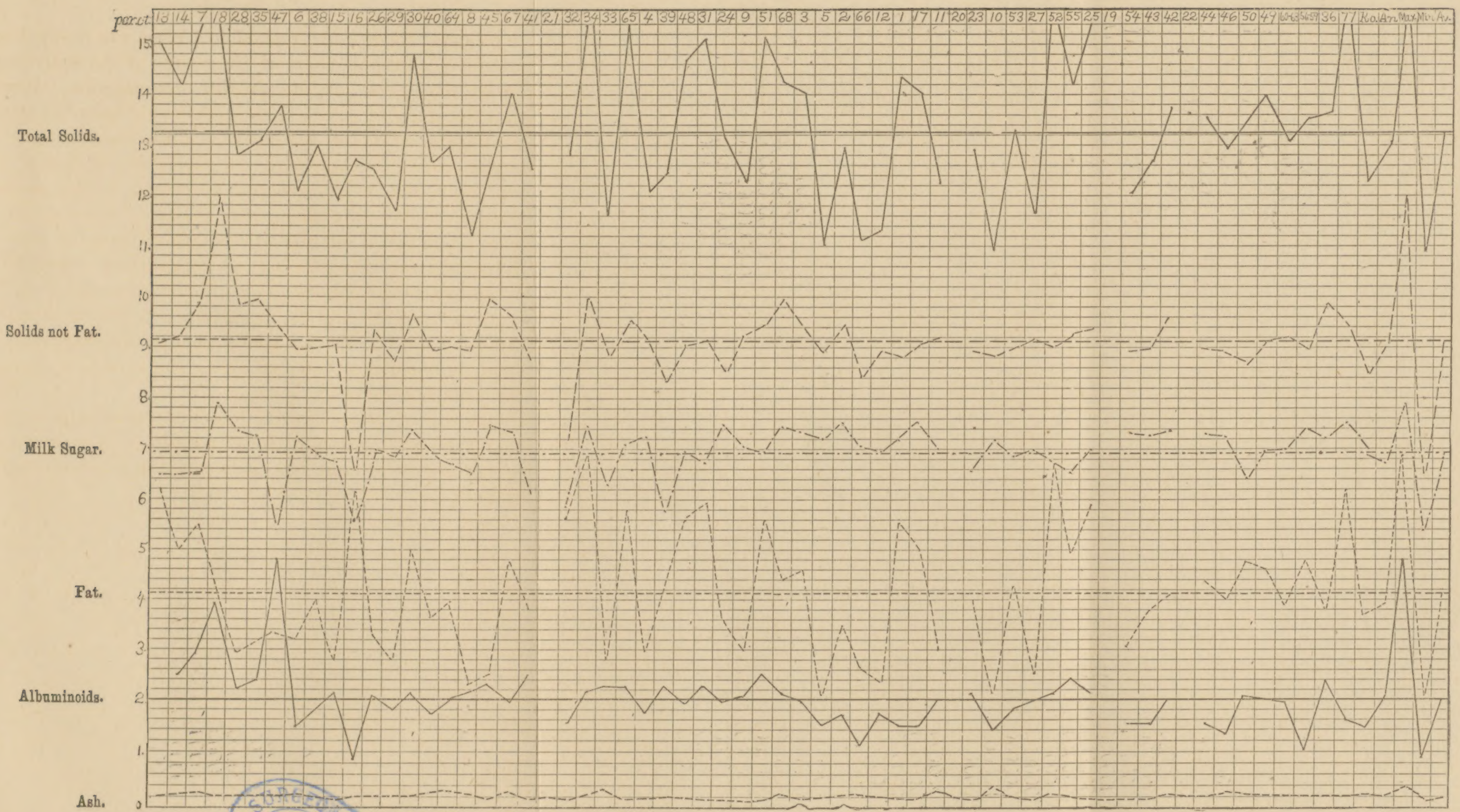
The difficulty of generalization upon these points can be most forcibly illustrated by comparing the analysis of sample No. 40, which was obtained from a negress, with the other samples, and with the general average. Neither in color, smell, or other physical characteristics, nor in chemical constitution, was this one sample so markedly different from the others as to be put, as some have proposed to do with the milk of negro women, in a class by itself.

V. *Physical Constitution of the Mother.*—A comparison of the physical characteristics of the mother, whether blonde or brunette, or more minutely, as to color of eyes, hair, complexion, etc., has not shown that these differences are necessarily related to corresponding differences in the composition of the milk. But actual differences in the physical condition of the mother are intimately related. The samples obtained from women of over-robust habit were not so rich in albuminoids as those from pronouncedly anæmic

women; and, generally speaking, the best milk was obtained from lean women in good physical condition.

Graphic Chart.—A great deal of labor was devoted to the preparation of a graphic chart of the results of the analyses performed during the course of the present investigation. It was thought that the study of such a chart might reveal some law governing the relative amounts of the various constituents, which law might escape notice in comparing merely tabulated figures. The chart represents the results grouped according to the period of lactation, and follows the same order as that of Table I. In case, however, a number of samples were obtained from the same mother on different dates, these analyses are represented consecutively. These exceptions to the general order of arrangements are to be noted in samples 7, 18, 28 and 35, in samples 15, 16, 26, 29 and 30, and in samples 1 and 17. The horizontal lines in the chart represent differences of one-fifth of one per cent.; the vertical columns represent the sample analyzed.

One feature the chart exhibits in the most striking manner, and that is the great variability in the constition of women's milk. The proportion of fat more especially varies in an exceedingly arbitrary manner.


per ct.
13 14 7 18 28 35 47 6 38 15 16 26 29 30 40 64 8 45 67 41 21 32 34 33 65 4 39 48 31 24 9 51 68 3 5 2 66 12 1 17 11 20 23 10 53 27 52 55 25 19 54 43 42 22 44 46 50 47 36 77 Ka An Max Mi Av
Total Solids.
Solids not Fat.
Milk Sugar.
Fat.
Albuminoids.
Ash.
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0